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THE PANAMA CANAL.

BY

GEORGE S. MORISON.

Many other routes have been proposed for isthmian transit, but in every instance, before much actual work has been done, the selection has finally turned to Panama, the successive choice of which by the Panama Railroad Company, by the Congress of Paris, and by the Isthmian Canal Commission confirms its merit.

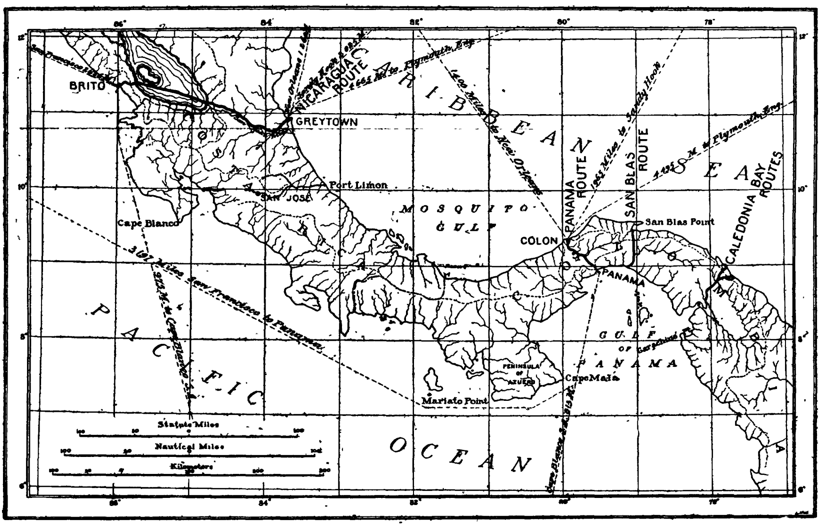


FIG. 1

In no one respect can the Panama route be considered the best. For convenience of access to all ports except those of South America, Tehuantepec is superior, but a summit 700 feet above tide water, too broad to tunnel or to cut through, makes it an impossible canal route. The San Blas route from Mandinga harbor, on the Caribbean side, to the mouth of the Chepo, in Panama Bay, has the best harbors, and is the shortest line between the two oceans; but the summit is four times as high as that at Panama, requiring a tunnel more than four miles long, which is fatal. The Nicaragua route has the lowest summit and the attractive feature of a great inland lake for its water supply. It is a practical route for a canal;

but the distance between the oceans is four times as great as at Panama; it is near the region of maximum volcanic disturbance; there are no existing harbors at either end, and for a distance exceeding the entire width of the isthmus at Panama the Nicaragua Canal must be built through a nearly uninhabited swamp, with a rainfall of over 200 inches a year, where the newly-upturned soil would be full of malaria; and this only brings it to the San Juan River, whose crooked channel must be improved and made navigable. There are three possible routes from Caledonia Bay to San Miguel Bay; the distance between tide water on each of them is about the same as at Panama; there are good harbors at each end; but all of these routes involve tunnels, although on one of them the summit is but little more than 600 feet high, and on another the length of tunnel can be kept within two miles. Various routes have been proposed between the Atrato River and the Pacific, but all of these involve a considerable length of canal in the delta of a great silt-bearing river and a length of inland navigation much greater than on either the Panama, the San Blas, or the Caledonia routes. While not possessing any single feature better than that of some other route, the Panama route has many less bad features than any of the others. It is for this reason that it has been so often selected as the best trans-isthmian line.

The Atlantic terminus of the Panama Canal is at Colon, in latitude 9° 22′ N. and longitude 79° 55′ W. The Pacific terminus is Panama Bay, in latitude 8° 55′ N. and longitude 79° 31′ W. It is a somewhat singular thing that the course of the canal is from northwest to southeast, and the Pacific end is 28 miles east of the Atlantic end. The length of the canal from shore-line to shore-line is 43 miles, and from the six-fathom contour to the six-fathom contour 49 miles, which distances can be reduced about a mile and a quarter by a change of location which will be mentioned hereafter.

The mean levels of the two oceans are the same. There is, however, an enormous difference in tides, the tide in the Caribbean Sea being hardly more than nominal, seldom amounting to two feet; while the tide in Panama Bay often exceeds 20 feet. If a tide-level canal were built a lock would be required near the Pacific end.

Colon harbor, at the sea end of the Bay of Limon, is a fairly good harbor, which has answered the demands of commerce for fifty years. It is, however, barely 30 feet deep, and is open to the sea on the northwest. When a storm blows in from this direction all shipping must put to sea; but the number of days in a year in which this harbor cannot be used is very small. Panama Bay is a great body of water with a number of islands in it, generally calm, and with abundant anchorage in protected locations; although a roadstead rather than a harbor, it answers all commercial demands. At low tide the city of Panama is surrounded by mud flats; there is no deep water anywhere near the shore; ships anchor in the bay three or four miles away, and cargoes are brought to the wharves by lighters during high water.

At Panama the actual width of the isthmus from tide water to tide water is only 35 miles in a straight line. The continental divide is about eight miles from the Pacific, and in places less than 300 feet above mean tide. Between this low mountain ridge and the Atlantic lies a hilly country intersected by streams the drainage of which is into the Atlantic through the Chagres River. The Chagres rises in the mountains about 45 miles east of Colon, and enters the Caribbean Sea some miles west of the Atlantic terminus of the canal. The valley of the Chagres, with the low country adjacent to it, forms a natural approach from the Atlantic side. To pass from this valley to the Pacific, it is necessary to go boldly across the low ridge of the Cordilleras. The route selected by the original French company for the Panama Canal is, in a general way, the same as that on which the Panama Railroad was built 30 years before; subject to variations of detail, the routes are practically one, and the only possible route in this part of the isthmus.

The Chagres is a tropical mountain stream, with the excessive variations of discharge which belong to such a river; its maximum flood discharge is approximately 300 times its minimum dry season discharge, which does not differ materially from the extreme range of many rivers in the United States. The area of its total drainage basin, though not completely surveyed, is about 1,200 square miles. It has a comparatively rapid fall, which is greatest near the source; at the point where the canal leaves the Chagres valley to cross the divide the bottom of the Chagres River is about 40 feet above mean tide. The principal difficulties of the northern portion of the canal, from Colon to Obispo, lie in the control of the Chagres River; the principal difficulty of the remainder is the summit cut. In a tide-level canal, such as the original French company proposed to build, these difficulties were virtually all. With the abandonment of the tide-level scheme and the adoption of a summit level reached by locks the problem of water supply for this summit level was added; but as the only source of gravity supply for such summit level is the Chagres River, the problems of the control of this river and of the use of its water to feed the canal become virtually one.

The summit of the divide in the Culebra Cut is less than 9 miles from Panama Bay and only about 12 miles from the six-fathom contour at mean tide in the waters of the Pacific, while it is 35 miles from Colon harbor; although to reach the six-fathom contour a channel must be excavated a mile further. As the summit of the divide marks the limits of the drainage basins, it may be said that three-quarters of the length of the canal is in the valley of the Chagres. This is not strictly true, as Colon itself is outside of the Chagres watershed; but the fringe of country along the ocean is always outside of the watershed of a river, and this is a matter of little real importance. It may be briefly stated that for two-thirds of its length the Panama Canal must follow the lower level of the valley of the Chagres, and that for three-quarters of its length it is within the drainage of the Chagres. The study of the Chagres River is, therefore, the first essential, if one would comprehend the conditions which the builders of the canal must meet.

After leaving the low valley of the Chagres, the canal passes, for eight miles, through a heavy summit cut, commonly known as the Culebra Cut. This cut exceeds in magnitude any excavation ever yet made, although the abnormally heavy work is confined to a single mile. This is the second great problem of the canal.

The failure to appreciate these two conditions in the early days of its work on the canal was one of the causes of the failure of the Lesseps scheme. A proper plan for the control of the Chagres should have been worked out before any large amount of work was done in the valley of the Chagres, and the execution of the work should have been on lines which would have been determined by that plan. The work of excavation should at first have been concentrated on the great Culebra Cut, all the energies of the company being from the start devoted to the expedition of this part of the work, which would necessarily consume a maximum length of time. With such a plan the comparatively easy work in the low country should have been postponed until it was known what would be done with the Chagres and until the time for the completion of the heavy summit work could be measured. Various schemes were proposed for keeping the floods of the Chagres out of the canal, including, among other things, an enormous dam and a tunnel by which the waters would be allowed to escape towards the Pacific without overflowing the dam. These were little more than visionary schemes, which actual conditions proved impossible. Beyond the construction of some parallel diversion channels in the valley of the Chagres, which channels were generally of inadequate size, the original French company did absolutely nothing towards the solution of the Chagres problem, and comparatively little excavation in the Culebra Cut.

The New Panama Canal Company has done a great deal to determine the real facts about the Chagres River, and has elaborated more than one plan for the control and utilization of that river. It has done no actual work in this way on the ground. It has done work in the Culebra Cut, where it has concentrated its efforts with a view to getting as deep an excavation as possible and showing the character of the material which that cut penetrates. This excavation has all been done with the machinery provided originally by the old company; it has been done in the form of a narrow cut on one side of the great cut, the form of excavation being what they called a cunette, and which leaves the cut in good shape for further work. While the machinery used for this work would not meet the general approval of American contractors, and while many things have been done under difficulties and at greater cost than would otherwise have been necessary, the actual work done in the Culebra Cut by the New Panama Canal Company has really been the most intelligent construction work yet performed on the isthmus either at Panama or elsewhere.

Besides these two great problems, there are others of lesser difficulty, but equally essential to the completion of the work. Of these, however, comparatively little need be said here. The most important are the locks, the dimensions of which will be somewhat more than those of any lock ever yet built; but they involve no features sufficiently in advance of what has already been done to raise any novel problems.

Apart from the great engineering features mentioned, the real problems which require most study and skill are the control and sanitation of the isthmus. The former will require military organization with the discipline and power which render military occupation effective; the latter will require a thoroughly-trained corps, charged, first, with the duty of eradicating disease, and, second, with the duty of preserving healthy conditions when those have once been obtained. The former will require vigorous action and, perhaps, some violent measures; the latter will require the continual surveillance which often tests character more than the more emphatic earlier issues.

CONTROL OF THE CHAGRES.

The Chagres is a tropical stream, subject to the extreme conditions which are found in this part of the world. The boundary of its drainage basin has never been fully developed. The Isthmian Canal Commission, however, sent a party across from Mandinga harbor to the head waters of the Chagres, which followed the river down to Colon. This work virtually fixed the limit of the valley in one direction. Of the total drainage area of about 1,200 square miles 875 are above the Bohio dam.

The rainfall on this area averages, approximately, 100 inches yearly, which, although high, is not so excessive in the tropics as it would be in a colder climate, and barely half what it is at Nicaragua. The months of least rainfall are February and March, and this dry season sometimes extends well into either January or April, or both. The other eight months form a continuous rainy season, a rainfall exceeding eighteen inches having been observed in every one of these eight months; while rainfalls exceeding twenty inches have been observed in May, August, October, November, and December. During eight months of the year the problem is to dispose of the water of the Chagres; during the other four it is to make sure of enough water for the use of the canal.

The valley of the Chagres may be divided into four sections for purposes of description. The lower section is between its mouth and Bohio, Bohio being the place where it is proposed to build a dam to impound the river through the next section into a lake. The second section is from Bohio to Gamboa, Gamboa being the point where the canal and railroad both leave the Chagres proper to pass through or over the divide. The third section is from Gamboa to Alhajuela, which is the site where it has been proposed to build a second dam and to impound the upper river in a second lake. The fourth is the portion above Alhajuela, and is practically an uninhabited country.

The following table gives the areas of the watershed above the three governing points and the proportional areas and discharges of water.

	SQUARE MILES.	P. C.	PERCENTAGE OF DISCHARGE IN		
			DRY SEASON.	WET SEASON.	ANNUAL.
Alhajuela	510	58	75	55	60
Gamboa	645	74	83	68	72
Bohio	875	100	100	100	100

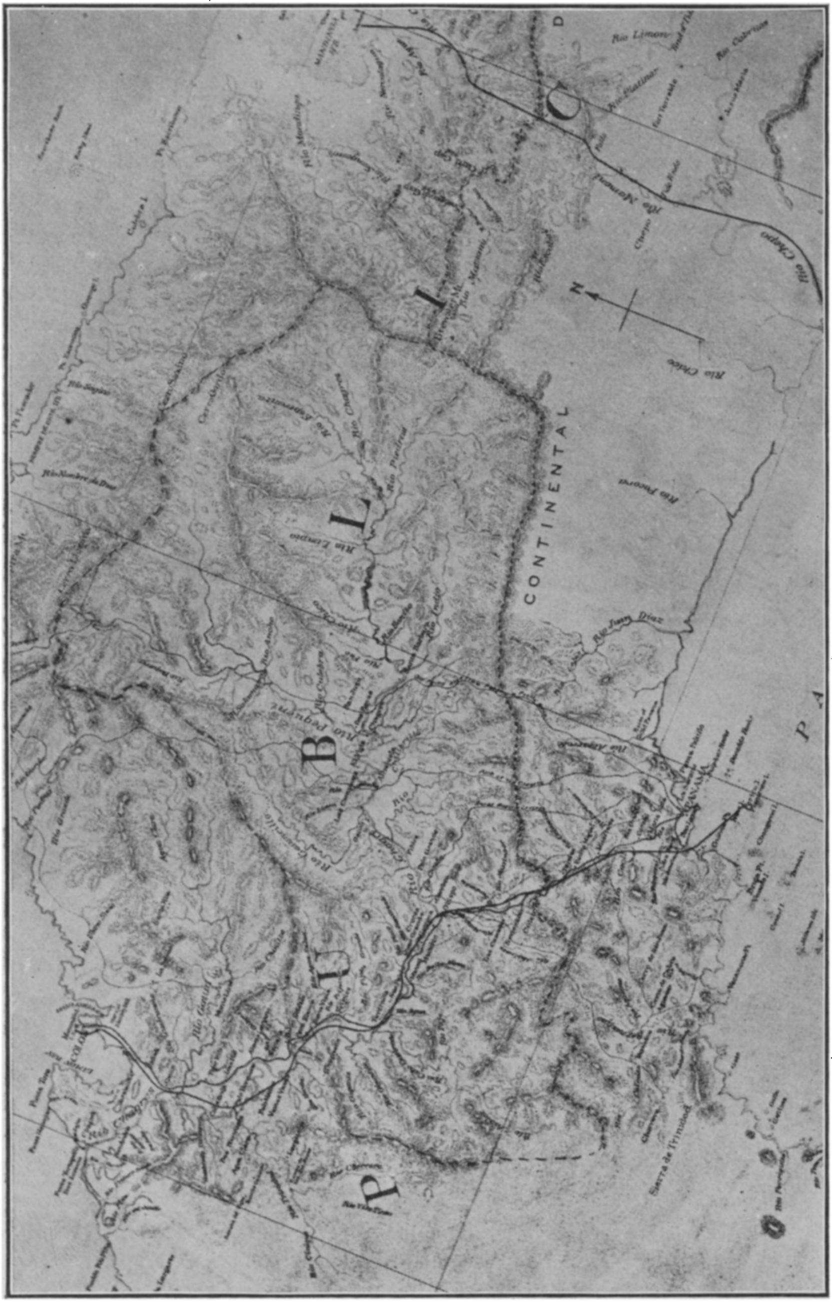

P
U
B
L
I
C
D
CONTINENTAL
P A
N
Rio Chagres
Rio Chico
Rio Pacora
Rio Juan Diaz
Rio Limpio
Rio Pequeni
Rio Gatun
Sierra de Trinidad
PANAMA
COLON

FIG. 2.

This is what occurs in normal conditions of the river as determined from the observations made by the New Panama Canal Company, the calculations being the special work of Gen. Henry L. Abbot, of the Engineer Corps of the United States Army, now retired, and who, as a member of the Comité Technique, was specially charged with this study.

Fifty-eight per cent. of the watershed of the Chagres, including only that above Bohio, is above Alhajuela. In the dry season seventy-five per cent. of the discharge comes from above Alhajuela. This shows that the conditions in the uninhabited mountain country above Alhajuela hold back the water during the wet season, to discharge it during the dry season, so that in the driest season the discharge of the river at Alhajuela is several times the amount of the rainfall above Alhajuela.

The upper Chagres, being that above Alhajuela, is practically a mountain stream; it runs between rocky banks, and is bounded by limestone cliffs. The water is clear, there is no alluvial deposit, and it is a beautiful mountain stream, which, apparently, has all the conditions to furnish a good water supply for the lower country and a good supply of water for the canal or any other purpose. The excellence of its water will probably be preserved while the country is inhabited only by those classes of animals which find their graves inside of other animals. Like all other rivers, it falls more rapidly near its source than below. The rapids are usually over rocks, but sometimes over boulders or very coarse gravel. Below Alhajuela there is more or less silt found in the banks of the river, and the conditions exist there which would make it in some measure a silt-bearing river. This has important significance in connection with the question of controlling the river.

Five great floods have been observed on this river.

DISCHARGE AT	1879		1885		1888		1890		1893	
	c. f.	p. c.	c. f.	p. c.	c. f.	p. c.	c. f.	p. c.	c. f.	p. c.
Gamboa...	78,600	61	64,500	86	58,100	75	65,400	93	43,100	85
Bohio.....	112,700	100	74,800	100	79,000	100	71,700	100	51,100	100

The greatest of these was that of 1879, which occurred immediately before the visit of M. Lesseps, with his party, to the isthmus. This flood was never measured; it has been calculated.

The three succeeding floods—in 1885, 1888, and 1890—which have been more carefully measured, did not differ very much, and were generally somewhat less than three-quarters the discharge calculated for the flood of 1879 at Bohio. It is to be observed that the flood of 1890 was very large at Gamboa. This was to be expected. The conditions of the extraordinary flood of 1879 must have been very much the same as those which have produced the extraordinary floods on the Ohio River in the United States—a rainfall distributed over several tributaries in such order that the maximum discharge of each enters the main river when that river is already swollen by the maximum discharges of the tributaries above.

These floods are of exceedingly short duration. They come up quickly, and go down quickly. The maximum discharge lasts only a few minutes. The excessive flood is seldom more than two days, and probably never more than three. Taking the maximum discharge of the Chagres at Bohio at 112,700, the minimum discharge is only about 350—that is, the maximum discharge is 350 times the minimum discharge. Great as this may seem, it is not out of proportion to the floods which we have on many of our American rivers.

The maximum and minimum discharges of the Tallapoosa River in Alabama are not only in the same proportion, but of nearly the same amount as the Chagres. In the Susquehanna, below Harrisburg, a maximum discharge of 750,000 cubic feet per second occurred in 1889, at the same time with the flood on the Conemaugh which destroyed Johnstown. The minimum discharge is probably not over 2,000 feet per second.

In one respect, however, the Chagres differs materially from these American rivers. The Tallapoosa, with a drainage area of about 3,000 square miles, produces the same results which the Chagres gets from a drainage area of less than nine hundred. The flood discharge of the Chagres, taken at Bohio, in the flood of 1879, was 129 cubic feet per second for every square mile of watershed; which is tremendous. This flood, if continuing for twenty-four hours, would correspond to a run-off of four and three-quarter inches of rain, all running off at the same time. Great floods, derived from a limited watershed, have given the Chagres its reputation; it is a little river, of small drainage area, with the floods of a big river. This, however, does not increase the difficulties of control. If you have to provide for 100,000 cubic feet per second, it makes no difference whether it comes from a thousand square miles or ten thousand square miles. The methods of control are the same.

There are three methods of controlling floods. One is by storage reservoirs. We have already one of nature's reservoirs on the upper Chagres, in the forests, and the general character of the soil. Another is by separate diversion channels. The third is by making the channel of the river itself, or of the canal, adequate to carry them off. All of these methods have been suggested.

Three reservoir schemes have been proposed. One would be formed by a dam at Alhajuela, which is an excellent place to build a dam; with rock banks and bottom, a masonry dam could be built here which would impound an immense supply of water, and practically reduce the amount to be taken care of in the lower river to the discharge of the lower basin. Another scheme was to build a dam for the same purpose at Gamboa—which would have been an excellent scheme if conditions had admitted of building a dam; unfortunately, no bottom could be found. The third proposition was to build a dam at Bohio; the Bohio dam would make the great Bohio lake, which is the solution of the Panama Canal question.

Separate diversion channels are objectionable. The canal must generally be in the lowest part of the valley. If the valley is broad, diversion channels are practicable. At Panama they are practicable below Bohio; they are not practicable above.

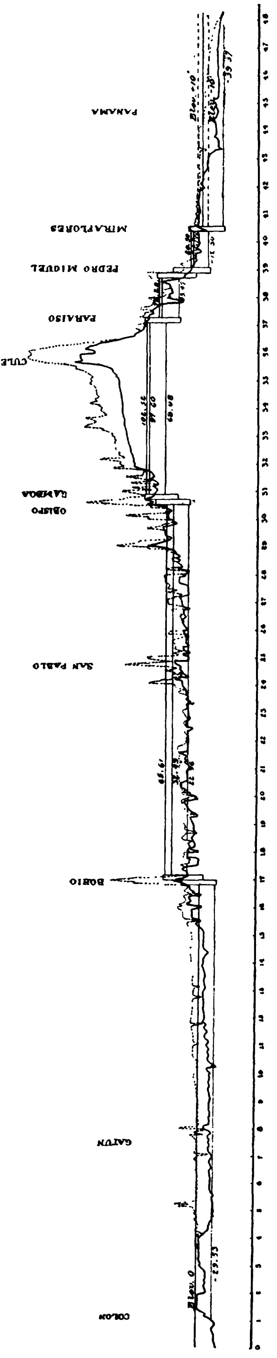
The third method, making the main canal big enough to carry off the floods, would require a canal with a bottom width of 400 feet. Such a canal would have the advantage of a very liberal waterway during ordinary stages. It might become silted up a little during the floods, but this could be removed easily by modern dredges; and the value of the additional waterway would more than balance the dredging expense. The writer considers this the only feasible way of carrying off the flood discharge if a tide-level canal is built.

The tide-level canal with this broad channel was estimated on by the Isthmian Canal Commission. In the writer's judgment, it would be the best canal when built; but it would take at least ten years longer to build than the canal with a higher level, and that additional time is fatal to the scheme.

The tide-level canal being set aside, the alternative is a canal with a summit level reached by locks, in which the great depth of the Culebra Cut can be reduced, and some other method than a broad channel found for the control of the Chagres. Such a high-level canal was proposed by Commander Lull, U. S. N., as early as 1875; his plan proposed to keep the canal everywhere well above the level of the Chagres, crossing the river on an aqueduct near Gamboa. Another high-level scheme was proposed in the latter days of the work of the Lesseps Company, although accepted by him only as a temporary measure. The New Panama Canal Company adopted a high-level scheme, in which a dam at Bohio converts the river above into a lake with the surface about 60 feet above tide water; from this lake the canal rises by two locks to a level 60 feet higher through the great Culebra Cut; this summit level is above the level of the Chagres, and was to be supplied with water through a complicated feeder from a second lake above the Alhajuela dam. After passing through the great cut, it descended, by a single lock at Paraiso, to a short level, thence by a flight of two locks at Pedro Miguel to a third level, and finally by a fourth lock at Miraflores to the level of the Pacific. While this plan was adopted by the New Panama Canal Company, it was manifest that the selection was based principally on the time required for construction, and that a plan, in which the level of Lake Bohio was carried through the Culebra Cut and the higher level with its complicated feeder avoided, would have been preferred if it could have been built in the same time. The plan adopted by the New Panama Canal Company required a flight of two locks at Bohio to ascend to the level of the lake, and a second flight of two locks at Obispo to ascend to the summit level, and four locks to descend from the summit level to the Pacific, of which two were grouped in a flight at Pedro Miguel, thus making eight locks in all.

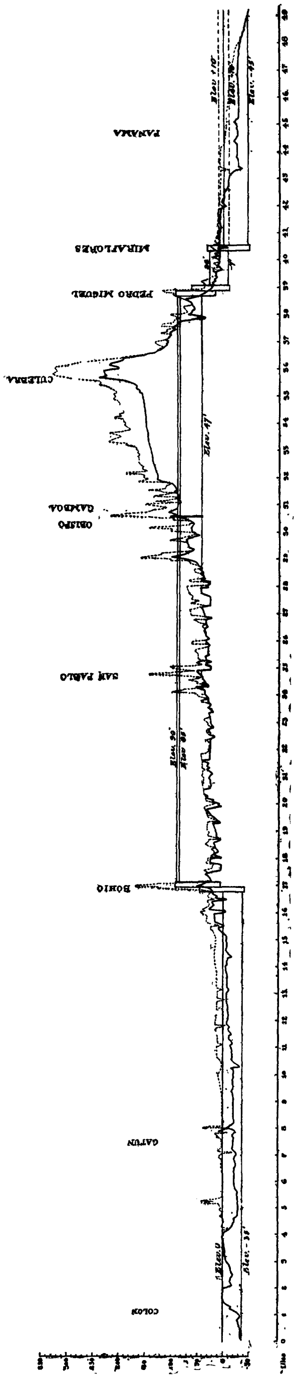
The Isthmian Canal Commission adopted a plan for a high-level canal differing from that of the New Panama Canal Company in that it raised the level of Lake Bohio from 60 to 85 feet above tide water, carried the level of the lake completely through the Culebra Cut, and dispensed with the second lake above the Alhajuela dam. By using a fixed spillway 2,000 feet long at the head of the Gigante valley, about four miles from the navigated course in the canal, the regulation of the lake was made entirely automatic and the discharge of the Chagres floods kept safely out of the line of the canal below Bohio. This plan requires a flight of two locks at Bohio to ascend to the lake, a flight of two locks descending at Pedro Miguel, and a single lock at Miraflores, making five locks in all.

The Commission's plan followed the same location as the French plan; but a modified route has been suggested, which will follow more closely the location of the Panama Railroad, shortening the distance by a mile and a quarter, on which route it would probably be expedient to use an intermediate level and place an additional lock at Tiger Hill.



NEW PANAMA CANAL COMPANY'S PLAN

FIG. 3.—PROFILE.



ISTHMIAN CANAL COMMISSION'S PLAN

FIG. 4.—PROFILE.

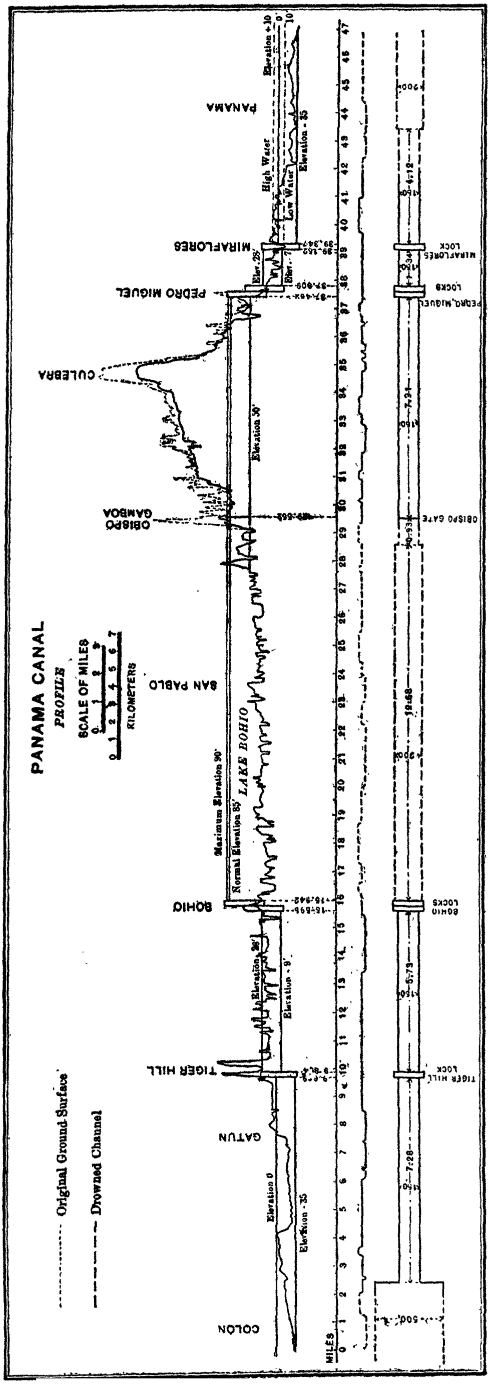


Fig. 5.—Tiger Hill Line.

In either of the two last plans Lake Bohio is the method of controlling the floods. It has an area of 40 square miles. When a great flood comes down the river the lake will begin to rise slowly, and by the time it has risen five feet will have reached its maximum, and the discharge over the spillway, three or four miles from the navigated course, will be taken away beyond the lower level of the canal. The lake is of such size that no flood will ever create a current in it exceeding that in the Detroit River, which is perhaps the best example of a North American navigable river. During all ordinary conditions the lake will simply have enough current to keep the water in it sweet. The dam and spillway are as complete a solution of the much-decried problem of the control of the Chagres as has ever been found for any great hydraulic question.

The water for the canal must come from the Chagres River, and during the low water season the supply is inadequate. About 1,000 cubic feet per second are required for the use of this canal, for evaporation and for other losses. The least discharge of the Chagres is about one-third of this; but this is a very rare occurrence. The entire deficiency between two seasons of high water has never exceeded 3,000,000,000 cubic feet, and this would be supplied by drawing down the level of the lake three feet. There are other methods of supply. One is the second lake above the Alhajuela dam. Another is the old Yankee device of flashboards, by which the lake could be maintained three feet above its normal level, the flashboards going out in extreme floods. In the writer's judgment, no provision should be made for low water until the canal is open for traffic. This would mean running the risk of having less than 35 feet of water in the summit level in extreme dry seasons. Flashboards could be used, if necessary, and if the deficiency was found troublesome, the Alhajuela dam could be built, after the canal was open to traffic, better than before.

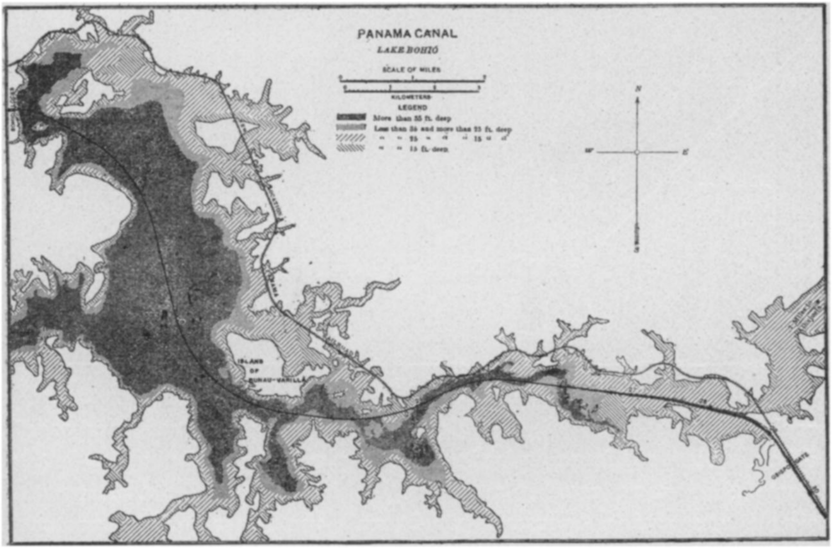


FIG. 6.

Lake Bohio is in itself an adjunct of great value. It is an interior harbor and an anchorage. It is absolutely land-locked, and the deep water runs into side valleys, where ships could be concealed. It will be a beautiful body of water, and in it will be an island of about 400 acres, which I have proposed to call the Island of Bunau-Varilla, in honor of the brilliant Frenchman who has never despaired of the completion of the Panama Canal, and to whose untiring energy we owe much.

CULEBRA CUT.

The Culebra Cut, meaning thereby the whole summit cut, is 7.9 miles long, with a maximum depth of 280 feet, and, according to the plans of the Isthmian Canal Commission, would have a bottom width of 150 feet and a depth of 35 feet below low water. The material is an indurated clay, which has a stratified formation, but which is not rock, although nearly as expensive to excavate as soft rock. There are in it some strata of hard rock and occasional dikes. It would have to be loosened by powder and given a flatter slope than rock usually requires. This cut will be the largest single excavation ever made. It will contain about 42,000,000 cubic yards of excavation. This sounds enormous, but it is only twelve times the volume of the great Pyramid; and if we of the twentieth century cannot handle twelve times as much earth or stone as the people who lived 6,000 years ago laid up in masonry, what are we to think of our modern civilization?

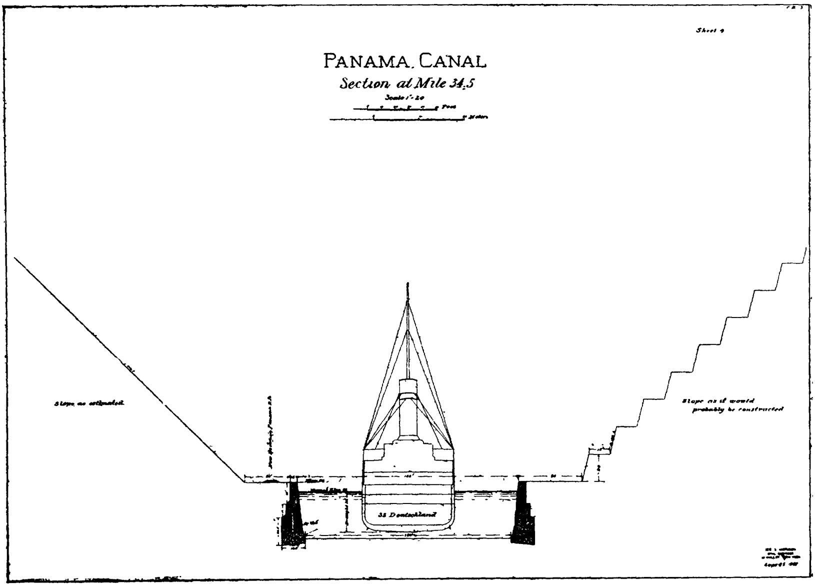


FIG. 7.

It is thought necessary to line both sides of the cut below water, and the best form of protection seems to be by two heavy masonry walls with nearly vertical faces, so that there will be no danger of ships striking them, and which will afford benches above, on one of which the track of the Panama Railroad can be laid, and which will catch any material which may slide down from the slopes of the cutting before it reaches the canal. The sides would probably be taken out in a series of benches connected by comparatively steep slopes, but the estimate has been based on an equivalent slope of one on one.

The locks proposed would have a greater capacity than locks that have ever been built for any work. They are to have a clear length of 750 feet and a clear width of 84 feet, with 35 feet of water at all stages over the mitre sills. The plans provide for duplicate locks everywhere.

The Isthmian Canal Commission's estimate was $144,000,000 to complete the work from its present condition, besides $40,000,000 to be paid to the French Company, but including no interest during construction. Great as this amount is, it is much less than a canal of equal capacity can be built for on any other line across the isthmus. Furthermore, with some modifications, which perhaps could be made to advantage, and by deferring the duplication of locks till a later time, the canal could probably be opened for traffic at a cost of $150,000,000, including the payment to the French Company, although not including interest during construction.

TIME OF TRANSIT.

The total distance from the shore end of the enlargement for Colon Harbor to the shore end of the wide channel through the mud flats in Panama Bay is 41 or 42 miles. This is divided into two canals by a lake more than 12 miles long in the middle; 13 or 14 miles of canal navigation, not including locks, lie between Colon Harbor and the Lake; a little more than 14 miles of canal navigation, not including locks, lie between Panama Bay and the lake. It is the navigation of these two canal sections which will regulate the passage across the isthmus. While the speed of steamers through the canal will vary with their size, the time which a ship of mean dimensions would take to pass through these two sections may be estimated as follows, the speed in the canal being taken at five miles per hour:

Colon Harbor to Tiger Hill lock, 7.28 miles	1	hour	27	minutes
Tiger Hill lock			45	"
Tiger Hill lock to Bohio locks, 5.73 miles	1	"	9	"
Bohio double locks	1	"	15	"
	4	"	36	"

Panama Bay to Miraflores lock, 4.15 miles		50 minutes
Miraflores lock		45 "
Miraflores lock to Pedro Miguel locks, 1.34 miles		16 "
Pedro Miguel double locks	1 hour	15 "
Pedro Miguel locks to Lake Bohio, 8.84 miles	1 "	46 "
	4 "	52 "

This time could be reduced for smaller vessels; it will be exceeded by the largest vessels. It may be said, in a general way, that the time required to pass from either ocean into the interior lake will not be less than four hours, and it should not exceed five hours, except for the very largest class of ships. To these figures should be added the time required to pass through the lake and the time lost in Colon Harbor or Panama Bay. It would, perhaps, be fair to add half an hour for each of these terminals, and an hour and a half for the passage of the lake; this would make the total time required for the passage of the canal from 10.5 to 12.5 hours.

Many steamers would take coal at Colon, and all would have to stop at the entrance port to pay tolls, take pilots, etc. There would be abundant room to tie up vessels in the broad harbor section at the Colon end. There is abundant anchorage in Panama Bay, the distance from the canal entrance to this anchorage being determined by the size of the ship and other considerations. There is ample room for ships to anchor and lie up in Lake Bohio, where they could get fresh water and, if necessary, make slight repairs. It is not probable that either section of canal would be traversed at night, except by the smallest class of vessels and in emergencies. Ships would probably prefer to enter the canal from either end about daylight or soon after noon. Ships entering in the morning would make a daylight passage, meeting in Lake Bohio. Ships entering afternoon would spend the night in Lake Bohio and pass out on the following morning, probably proceeding under dispatch orders and meeting the in-bound ships at the locks. The Tiger Hill lock, if used, will be approximately half-way between Colon and Lake Bohio, and the Pedro Miguel locks are approached in about the same length of time from the lake and from Panama Bay.

CONDUCT OF WORK.

The Isthmus of Panama has had a bad name for centuries. The climate is not a healthy one. It has been a transit line since the early Spanish occupation, and is inhabited by a mixed population of the lowest type. No systematic sanitary work has ever been undertaken. There is an abundance of excellent water in the

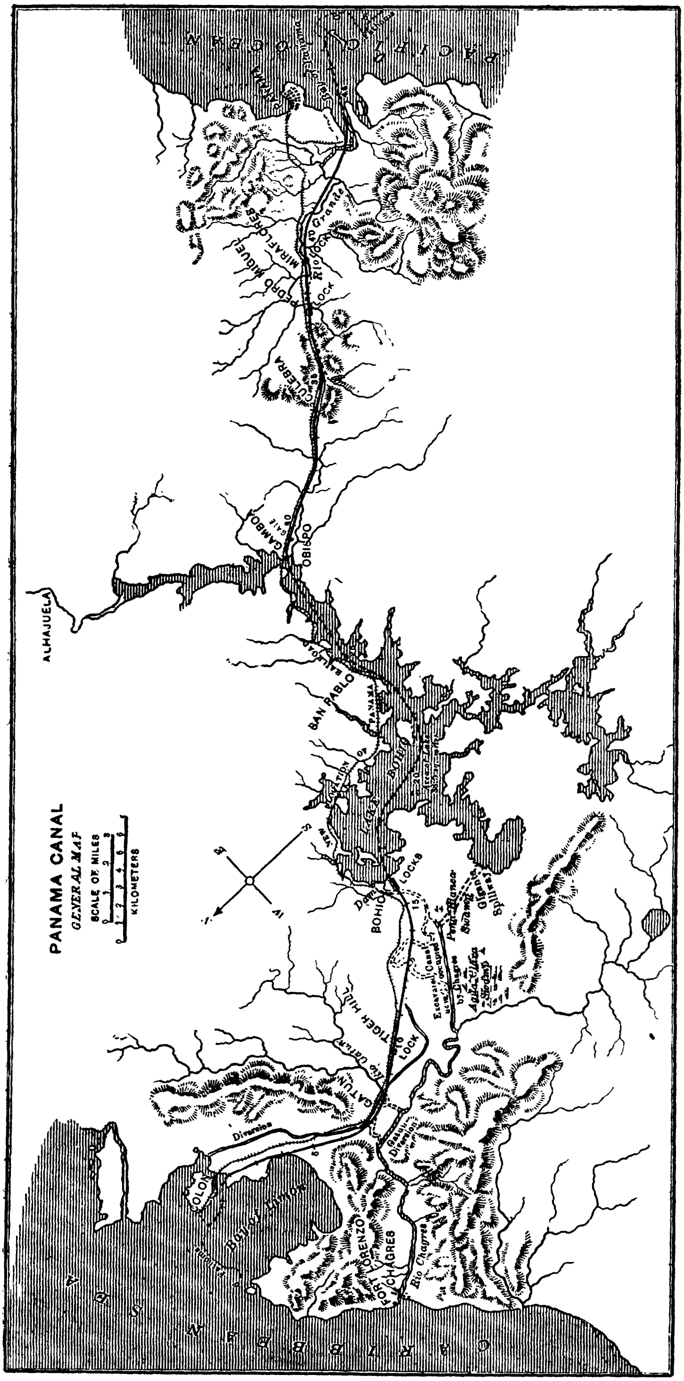

PANAMA CANAL
GENERAL MAP
SCALE OF MILES
KILOMETERS
PACIFIC OCEAN
CARIBBEAN SEA
ALHAJUELA
GAMBOA
OBISPO
CULEBRA
PEDRO MIGUEL
MIRAFLORES
Rio Grande
LOCK
SAN PABLO
BOHIO
LOCKS
Dam
LAKE BOHIO
Excavated Canal
Peña Blanca Swamp
Gigante Spillway
Agua Clara
TIGER HILL
Rio Gatun
GATUN
Diversion
COLON
Bay of Limon
FORT LORENZO
CHAGRES
Rio Chagres
Gatun Diversion
E
W
S

FIG. 8.

mountain streams, but no village or city has a water supply. There is no sewerage. The women wash the soiled clothes in the streams and the people get their water from the same streams. Nearly every vile disease may be found there, and the filth of centuries is kept under some of the houses. It is a tropical country living under the same sanitary conditions which fostered the plague in temperate Europe during the Middle Ages. The death-rate is higher in the dry season than in the wet season, which tells the story of the contamination of the water. The first thing to do is to clean the isthmus, to provide sewers where feasible and sanitary rules everywhere, to furnish the entire line with good drinking water, of which a great abundance may be had at moderate expense, and to compel the employees on the canal to drink nothing else. This will take at least a year.

The plans made by the New Panama Canal Company were unusually complete for preliminary work of this kind; but they were for a canal of different dimensions, with many details which would not be acceptable to American builders. The plans and examination of the Isthmian Canal Commission were made for purposes of estimate and for preliminary work rather than for actual construction. The final working designs remain to be made. Specifications must be prepared, and all the necessary preliminaries which precede the letting of contracts for so great a work must be completed. Both the home and local organizations must be perfected. Much of this work can be done simultaneously with the sanitary preparations, and will take as long. A year spent in preparation before the contracts are let will save time in the end.

After the contracts are awarded the contractors should be allowed another year to perfect their preparations. This is little enough time to provide for the organization of their forces and the purchase and collection of their machinery, much of which will have to be built after the contracts are awarded.

In two years after the transfer of the French property, and the beginning of American occupation, actual construction work should fairly begin. The one greatest single piece of work is the Culebra Cut, and the time required to complete this cut will be the time which it will take to build the canal. All other work should be laid out with reference to this, so that when it is completed there will be no unfinished work to delay the opening of the canal.

The bulk of the laborers must be West Indian negroes, from Jamaica and, perhaps, some other islands. Skilled labor must come from the north, and generally be white. The methods of work should be so designed that the number of skilled workmen shall be as small as possible, and that they shall be protected from rain and sun when at work. It will probably be expedient to use electric power instead of steam as far as possible. A dam at the site of the Alhajuela dam would furnish the power. If electrical shovels could be used instead of steam shovels, but one skilled man instead of two would be required at each shovel, and the heat from the boiler would be avoided. Although active disease may be exterminated, the debilitating influences of the damp, warm climate will remain, and a system of furloughs must be arranged which will permit the white employees to recuperate in northern climates about once a year.

The French companies were private corporations, working with no greater powers than those derived from their concessions. All this will be changed when the work becomes a Government undertaking. The powers of the United States will be those of military occupation, under which sanitary control and discipline can be exercised, which should remove the greatest difficulties which have hitherto beset the Isthmus of Panama. When the work is completed the malarial spots in the interior will have been replaced by Lake Bohio, and the condition of the isthmus should be no worse than that of other damp tropical countries. Lake Bohio, surrounded by hills and mountains, will be a beautiful and accessible body of water, traversed by frequent steamers, with all convenient connections with the ports of other countries. The surrounding hills will add beauty to the landscape and furnish sites for gardens and residences. It is not impossible that this region, which has been regarded as one of the world's pestholes, will in time become a favorite winter resort.

NEW YORK, December 23, 1902.